

I CLAIM:

1 1. A rotary tool for drilling into a soil formation from
2 its surface, controllably injecting water and binder at known
3 depths below the surface of said formation, and mixing said soil,
4 water and binder to form an in-situ piling, said tool comprising:

5 a rotary shaft having a central axis of rotation
6 adapted to be driven bi-directionally around said axis, and bi-
7 directionally along said axis;

8 a vane on and extending radially from said shaft to be
9 rotated around and moved axially by said shaft, said vane being
10 so disposed and arranged as to move through the formation along a
11 helical path to drill into said formation, to stir the material
12 of the formation, and ultimately to mix the material of the
13 formation with water and binder;

14 a water injector and a binder injector carried by said
15 tool, each injector having a respective axis of emission of water
16 or of binder, said axes of emission being directed away from said
17 tool into said formation at a respective location along said
18 central axis;

19 said injectors being so disposed and arranged relative
20 to one another that the material of their emissions will during a
21 limited number of revolutions of said shaft, encounter one
22 another, then to be mixed as a pre-determined ratio of water and
23 of binder, said water including water emitted from the water

24 injector and water which may have already been present at that
25 location.

1 2. A rotary tool according to claim 1 in which said
2 injectors are set in said shaft with their axes of emission
3 substantially normal to said central axis, and located along said
4 central axis such that the emission of one of them will, within a
5 limited number or rotations of the shaft encounter and mix with
6 the other in a temporally suitable time related to the curing of
7 the binder and drainage of the water.

1 3. A rotary tool according to claim 2 in which said
2 injectors are disposed about 180 degrees apart as viewed in
3 lateral section.

1 4. A rotary tool according to claim 1 in which the said
2 water injector and binder injector are provided as a pair, their
3 axes of emission intersecting adjacent to said shaft under in-
4 situ pressure whereby to produce a mixture of water and of binder
5 with a velocity having a radial component of motion.

1 5. A rotary tool according to claim 1 in which said binder
2 injector is surrounded by a plurality of water injectors, the
3 axes of emission of said water injectors intersecting the axis of

4 emission of the binder injector

1 6. A rotary tool according to claim 1 in which said
2 injectors are set in said vane at a radial distance from said
3 shaft.

1 7. A rotary tool according to claim 6 in which the said
2 water injector and binder injector are provided as a pair, their
3 axes of emission intersecting adjacent to said shaft under in-
4 situ pressure whereby to produce a mixture of water and of binder
5 with a velocity having a radial component.

1 8. A rotary tool according to claim 2 in which a pair of
2 said water injectors and at least one of said binder injectors
3 are set in said shaft, with said binder injector located axially
4 between said water injectors.

1 9. A rotary tool according to claim 2 in which a pair of
2 said binder injectors and at least one of said water injectors
3 are set in said shaft, with said water injectors located axially
4 between said binder injectors.

1 10. In combination:
2 a rotary tool according to claim 1; and

3 ... a control valve respective to each of said injectors,
4 whereby the rate of supply of water and of binder can
5 independently be regulated by said control valve to provide
6 binder at a rate desired at a respective depth and water at a
7 rate desired which with existing water already in the formation
8 at that depth, will constitute at least sufficient water for
9 stoichiometric reaction of the binder.

1 11. A combination according to claim 10 in which a program
2 controls said control valves to establish the rates of supply of
3 the binder and the water.

1 12. A combination according to claim 11 in which said rates
2 are related to already known water conditions and binder
3 requirements at respective depths below said surface.

1 13. A combination according to claim 11 in which said rates
2 are related to water conditions sensed at depths below said
3 surface.

1 14. A combination according to claim 10 in which said
2 injectors are set in said shaft with their axes of emission
3 substantially normal to said central axis, and located along said
4 central axis such that the emission of one of them will, within a

5 limited number or rotations of the rotary tool encounter and mix
6 with the other in a temporally suitable time related to the
7 curing of the binder and drainage of the water.

1 15. A combination according to claim 10 in which the said
2 water injector and binder injector are provided as a pair, their
3 axes of emission intersecting adjacent to said shaft under in-
4 situ pressure whereby to produce a mixture of water and of binder
5 with a velocity having a radial component of motion.

1 16. A combination according to claim 10 in which said binder
2 injector is surrounded by a plurality of water injectors, the
3 axes of emission of said water injectors intersecting the axis of
4 emission of the binder injector.

1 17. A combination according to claim 10 in which said
2 injectors are set in said vane at a radial distance from said
3 shaft.

1 18. A combination according to claim 10 in which a pair of
2 said binder injectors and at least one of said water injectors
3 are set in said shaft, with said water injectors located axially
4 between said binder injectors.

1 19. Apparatus according to claim 1 in which a baffle is
2 fixed to each said vane to confine emissions from said injectors
3 to the region encountered by said vanes.

1 20. The method of forming an in-situ piling in a soil
2 formation with binder and sufficient water to produce a
3 stoichiometrically correct mixture, comprising:
4 with a rotary tool, drilling into said formation, said
5 tool having a rotary shaft that has a central axis of rotation
6 and a vane for drilling into and mixing the soil, rotated around
7 and moved axially by said shaft, said vane being so disposed and
8 arranged as to move through the formation along a helical path to
9 drill into said formation, to stir the material of the formation,
10 and ultimately to mix the material of the formation with water
11 and binder;

12 a water injector and a binder injector carried by said
13 tool;

14 driving said tool axially into and out of said
15 formation while rotating it;

16 at some times during axial movement of said tool,
17 discharging water or binder from a respective injector into said
18 soil formation along a respective axis of emission of water or of
19 binder, said axes of emission being directed away from said tool
20 into said formation at a respective location along said central

21 axis, so that the material of their emissions will during a
22 limited number of revolutions of said shaft encounter one
23 another, there to be mixed as a pre-determined ratio of water and
24 of binder, said water including water emitted from the water
25 injector and water which may have already been present at that
26 depth.

1 21. The method of claim 20 in which injection of binder is
2 made during passage of said tool into said soil formation.

1 22. The method of claim 20 in which injection of binder is
2 made during passage of said tool out of said soil formation.

1 23. The method of claim 20 in which injection of water is
2 made during passage of said tool into said soil formation.

1 24. The method of claim 20 in which injection of water is
2 made during passage of said tool out of said soil formation.

1 25. The method of claim 20 in which the emissions of said
2 injectors intersect adjacent to said shaft.

1 26. The method of claim 20 in which the emission of one of
2 said injectors is encountered in said soil formation in a

3 temporally suitable time related to the curing of the binder and
4 drainage of the water.

1 27. The method of claim 20 in which the emission of water
2 id determined by a program responsive to data from a
3 representative core.

1 28. The method of claim 20 in which the emission of water
2 is determined by a program responsive to data relating to water
3 content already in the soil derived from a sensor on said tool
4 disposed at an axial location below the place of injection of
5 said binder.

1 29. The method of claim 20 in which the pressure of the
2 stream of water and of the binder in the tool is above the
3 ambient pressure which exists in the formation.